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INSTITUTE FOR DEFENSE ANALYSES

IDA Document D-2527

Assessment of Instrumentation at Camp Lejeune

Dennis DeRiggi

PREFACE

This document was prepared under the MOUT ACTD in order to provide the Technology Program Manager with a set of options regarding the disposition of the instrumentation in the MOUT site at Camp Lejeune. It summarizes the results of an assessment of the instrumentation conducted by Lockheed-Martin and STRICOM in January 2000. The author would like to give special thanks to Ben Covington who took part in many of the activities at Camp Lejeune and Quantico, including interviews, discussions and presentations, that formed much of the background for this report. Also, the author would like to thank the reviewers, Mr. Charles Lyman and Mr. Dale Schoenberger for their careful reading and helpful suggestions. Finally, the author wishes to express his gratitude to the editors, Ms. Eileen Doherty and Ms. Barbara Varvaglione, for their valuable help in preparing this document.

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SUMMARY

A. PURPOSE

This paper is an assessment of the instrumentation at the Camp Lejeune Military Operations in Urban Terrain (MOUT) site. It presents an examination of the existing equipment and supporting software, an evaluation of their combined functionality, and an estimate of the cost of repairs and upgrades.

The purpose of the instrumentation assessment was twofold: to determine the status of the existing system, and to formulate options or possible courses of action for the Technology Program Manager of the MOUT ACTD with respect to the disposition of the instrumentation. This evaluation relies heavily on the recent activities (December, 1999 through January, 2000) on the part of Lockheed-Martin engineers who inspected the site and tested much of the existing equipment[1]. Recommendations to the Technology Program Manager are based largely on cost estimates derived from this effort and from discussions and interviews conducted with PM Training Systems, MARCORSYSCOM.

1. The Site

The MOUT site consists of over 20 buildings. Four of these – the Church, Bank, Gym and Strip Mall – are instrumented and will be the focus of this report. The Operations Center (OPCEN) is not one of the MOUT buildings per se; it is the coordination and after-action-review facility (described in more detail below) from which exercises were controlled and directed.

2. Equipment

The MOUT Instrumentation System (MOUT-IS) at Camp Lejeune is a collection of sensors, lasers, microwave and RF equipment, computers, and accompanying software that enable the USMC to develop and refine TTPs by analyzing the detailed interactions

[1] Much of this paper is based on Lockheed-Martin report DO #0130 – CDRL AB01, *Military Operations in Urban Terrain – Instrumentation System Assessment*, May, 2000

of engagements in urban/restrictive terrain. The main text of this report describes the components of MOUT-IS and highlights some of their interrelationships.

B. ASSESSMENT PROCESS

1. Phases

The assessment of the state of instrumentation at Camp Lejeune was conducted in two phases. The first phase was executed between January 12th and 14th, 2000, by a team of engineers from Lockheed Martin's Orlando facility. The purpose of this first phase was to perform an inventory and rapid inspection of the equipment at the MOUT site. This overview provided a basis for estimating the level of effort that would be required for a more in-depth inspection (the second phase).

The first-phase inspection revealed that most of the instrumentation equipment at Camp Lejeune was intact. The only significant exception was the damaged microwave antenna outside one of the buildings. This antenna and its associated electronics were destroyed when a helicopter blade struck the antenna housing. Some indoor equipment was damaged slightly from moisture and mildew.

The second phase was conducted on-site at Camp Lejeune during the last two weeks of January, 2000. This phase involved the actual operational testing of sensors, weapons, and computers. Due to time and resource constraints (imposed in large part infrastructure degradation due to the lack of routine maintenance), however, this was not a full-up drill with all equipment synchronized and running in concert. Instead, this was a test of individual subsystems and the MILES 3rd Generation equipment on a largely sequential basis.

In the second phase, all indoor and outdoor tracking equipment was activated and initialized using software resident in the OPCEN or within the equipment itself. Actual testing took place in the following facilities: OPCEN, MILES warehouse, strip mall, bank, gymnasium, and the church. Typically, this testing entailed unpacking and booting computing equipment, testing some of the sensor equipment, setting up antennae, and installing transponders to verify measurements taken by player equipment.

2. Findings

The IRPS was functional. By setting up a collection of transponders, the assessment team was able to establish that the system successfully tracked a player unit. Helmet

transponders are in need of new batteries, however, and their transponders need to be reprogrammed with the new identity codes. The microwave link between instrumented buildings and the OPCEN is not functional and should be replaced by hardwire cable.

The OPCEN computers are obsolete and should be replaced. Their operating systems are outmoded and should be upgraded.

The RF repeater network contains obsolete equipment and should be upgraded. Some portions of this network could not be tested due to missing equipment. The microwave link between the repeaters and the OPCEN could not be established and should be replaced by hardwire cable. Also, the GPS cards are not compatible with the August, 1999, satellite system upgrade.

In many cases, the player equipment, such as MILES grenades or direct-fire-vest sensors, failed to operate. Often these failures were traced to batteries that had become corroded over long periods of disuse or lost power due to extremely cold conditions.

3. Repairing the System

In order to restore the instrumentation at the Camp Lejeune MOUT to an operational level, it will first be necessary to replace outdated or damaged equipment. For example, most of the RF equipment and GPS cards in the repeater cabinets are obsolete. So too are the OPCEN computers and their operating systems. Microwave links are damaged or unreliable and should be replaced by hardwire cable.

Second, all 3.6-volt batteries in SATs, player vests, and helmet sensors should be replaced. Many of these batteries have oxidized and no longer are reliable power sources. Similarly, all 5.0-volt batteries in MILES grenades should be replaced. Detailed testing — possibly at the laboratory level — should be conducted on many types of equipment. Candidates include all MILES direct fire vests, helmet sensors, grenades, and SATs.

Third, both the indoor instrumentation and the range repeaters should be subject to continuity and power checks. Player equipment should be packed and shipped to Orlando, FL, for laboratory testing — then boxed and shipped back. Both the indoor instrumentation and the OPCEN computers should be subjected to tests in which all systems are up and running (equipment tests in the assessment phase were largely conducted in a sequential stand-alone manner).

C. COST ESTIMATES

1. Repairs and Maintenance

This section summarizes the costs of repairing and maintaining the instrumentation at Camp LeJeune. Estimates are based on the number of engineering hours required to perform the repairs plus the expected material costs. These are presented (in the main text) for the four major instrumentation subsystems: indoor instrumentation, OPCEN computers, range repeaters, and the MILES player equipment.

In order to maintain the instrumentation suite after it is repaired and restored, it will be retain the services of key technical and operational personnel. Expected staffing will include the site manager, the OPCEN computer operator, and two technicians.

These positions are expected to be full-time. If the average wage is $50/hour, then the annual personnel cost of maintaining the facility is $400K. Routine repairs and materials might add another $100K per year.

2. Removal and Relocation

Once the repairs have been made, it may be more desirable to remove the instrumentation suite to an alternative site rather than retain it at Camp Lejeune – say for support or resource reasons. Were this to be the course of action, the subsystems (indoor instrumentation, OPCEN equipment, range repeaters, and MILES gear) would have to be inventoried, removed, and packed. Cosmetic repairs would have to be performed and shipping arrangements made. At the receiving site (assuming it meets structural and power criteria), it would be necessary to conduct surveys, unpack equipment, and prepared buildings to receive the instrumentation.

The “labor and parts” for these operations are estimated and combined with the repair data to give the total repair and relocation costs. This is shown in the main report.

D. CONCLUSION

The Lejeune MOUT site is used on a regular basis to train Marines to conduct operations in urban terrain. The site contains over 20 buildings. However, the four instrumented buildings, the church, gymnasium, bank and strip mall, are not used during training

exercises. While the rationale for excluding these buildings is not entirely clear[2], it is nonetheless apparent that the presence of inoperative instrumentation has a negative impact on the MOUT facility.

If it is unlikely that the instrumentation at Camp LeJeune will be returned to working order, due to prohibitive maintenance costs or any other reason, then two options should be considered. Either the instrumentation suite should be dismantled and discarded, or an alternative MOUT site should be considered. In either case, the all buildings at Lejeune would become available for training instead of the approximately 16 out of 20 that are available now.

The second option, an alternative site, has certain attractive features: the "sunk costs" of the Lejeune site would be partially recovered and an active facility would become available. One candidate site is the MOUT facility ("Range 9") at Quantico, VA. While this un-instrumented facility is smaller than Lejeune's (only 15 buildings as compared to over 20), it has the advantage of being available to the USMC and a wide variety of government agencies (FBI, DEA, Capitol Police, etc). Furthermore, the PM Training Systems at Quantico is interested in developing the facility and would welcome an instrumented site.[3] The instrumentation suite at Lejeune – pending an endorsement of the transfer by the Marine Corps Warfighting Laboratory – could be the basis for such a facility.

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[2] The MOUT facility at Camp Lejeune falls under the authority of the II Marine Expeditionary Force (II MEF), while the instrumentation at the site is controlled by the Marine Corps Warfighting Laboratory. This dichotomous arrangement may have bearing on the disposition of the site.

[3] As evidence of their interest, the PM for Training Systems/MARCORSYSCOM at Quantico is acquiring enough MILES 2000 equipment to outfit 10 battalions.

I. BACKGROUND

A. PURPOSE OF ASSESSMENT

This paper is an assessment of the instrumentation at the Camp Lejeune Military Operations in Urban Terrain (MOUT) site. This assessment is based on an examination of the existing equipment and supporting software, and consists of an evaluation of their combined functionality as well as an estimate of the cost of any necessary equipment repairs or software upgrades.

The purpose of the instrumentation assessment is twofold: to determine the status of the existing system and to formulate options or possible courses of action for the Technology Program Manager of the MOUT Advanced Concepts Technical Demonstration (ACTD) with respect to the disposition of the instrumentation. This evaluation relies heavily on the recent activities (December, 1999 through January, 2000) of Lockheed-Martin engineers who inspected the site and tested much of the existing equipment.[1] Recommendations to the Technology Program Manager are based largely on cost estimates derived from this effort and from discussions and interviews conducted with PM Training Systems, MARCORSYSCOM.

B. COMPONENT DESCRIPTION

Before embarking on a detailed description of the instrumentation at Camp Lejeune, it will be helpful to describe the layout of the site itself. The MOUT site consists of over 20 buildings. Four of these – the Church, Bank, Gym, and Strip Mall – are instrumented and will be the focus of this report. Figure 1 is an aerial view of the site, showing the building sites in relationship to the other buildings. The Operations Center (OPCEN) is not one of the MOUT buildings per se; it is the coordination and after-action-review facility (described in more detail below) from which exercises are controlled and directed.

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[1] Much of this paper is based on Lockheed-Martin report DO #0130 – CDRL AB01, *Military Operations in Urban Terrain – Instrumentation System Assessment*, May 2000.

Figure 1. The Camp Lejeune MOUT Facility (with highlighted instrumented buildings)

The MOUT Instrumentation System (MOUT-IS) at Camp Lejeune is a collection of sensors, lasers, microwave and RF equipment, computers and accompanying software that enable the USMC to develop and refine Tactics, Techniques, and Procedures (TTPs) by analyzing the detailed interactions of engagements in urban terrain. The major components of MOUT-IS are positioning systems that measure the location of player/combatants both inside and outside buildings, and weapons simulators that both enable engagements to take place among combatants and report the outcomes of these engagements to a coordination center. The following paragraphs describe these MOUT-IS components and highlight some of their interrelationships.

1. In-Room Positioning System (IRPS)

Two buildings in the Lejeune MOUT site are instrumented for the In-Room Positioning System or IRPS: the Strip Mall (Building 10) and the Bank (Building 17). The IRPS consists of a collection of ultrasonic receivers and infrared emitters in each building, a building computer, and helmet transponders worn by the individual players. Each player's transponder detects infrared signals from the room's grid of emitters and, in turn, emits an ultrasonic pulse. This pulse is detected by the network of receivers in the room

and, through triangulation, determines the player's location and identity. These data are sent to the Operations Center (OPCEN, Building 20) over the microwave LAN.[2]

2. GPS

The Global Positioning System (GPS) is used to track players outside buildings. Each player's harness is equipped with GPS antenna and receiver; GPS signals are received directly from the satellite constellation, then modified by a differential GPS correction supplied by the OPCEN. The resulting position estimates, which are accurate within a few meters, are relayed (see description of the communications infrastructure, below) to the OPCEN, where tracks for individual players are displayed.

Global positioning antennae are located on the school Gymnasium (Building 16), the Church (Building 7), and the OPCEN. Three antennae are required to eliminate "shadow" areas.

3. The Communications Infrastructure

Player positions and status are transmitted to the OPCEN through a collection of radio frequency repeaters (RF) and microwave local area networks (LAN). Two separate sets of microwave LAN are employed in MOUT-IS: one for indoor positions, the other for outdoor. Indoor player positions are transmitted to the OPCEN via microwave antennae that connect the OPCEN with the instrumented buildings. Outdoor player positions, along with player status and direct or indirect-fire event data, are transmitted[3] to the repeater network via RF communications. This information is then transmitted to the OPCEN over a separate set of microwave LAN. Data packets received at the OPCEN are collected and logged so that "engagements" may be played back, critiqued, and analyzed.

Range repeaters are located in the school Gymnasium and the Church. These repeaters convert RF signals from the players transmitters into digital data (and transfer these

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2 The IRPS estimates player locations to within six inches, the degree of accuracy required to determine player positions relative to walls. Updates are made at least once a second (for up to 33 players). The period between updates increases nearly linearly when the number of players exceeds 33.

3 Typical update period is on the order of five seconds. During periods of increased activity, updates may occur at a higher frequency so that "data logging" will capture critical events in a smooth manner.

digital signals to the OPCEN over the microwave LAN). Microwave antennae are located on the Gym, Church, OPCEN, Strip Mall (Building 10) and – until a recent helicopter accident – the Bank. The communications system is depicted in a schematic diagram in Figure 2, below.

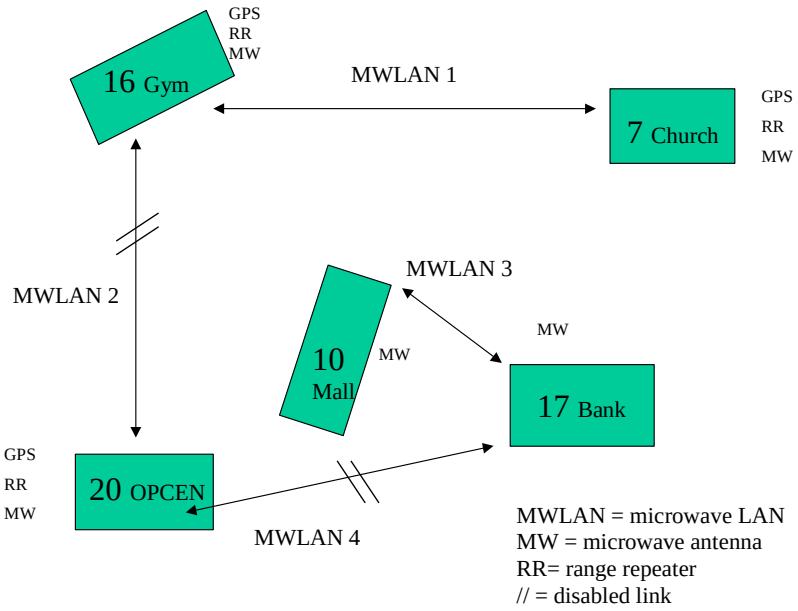

Figure 2. MOUT Range Instrumentation

4. Multiple Integrated Laser Engagement System (MILES)

Standard player equipment includes the Lockheed Martin 3rd Generation Multiple Integrated Laser Engagement System, or MILES, "gear." This is a system of sensors and communications hardware that evaluates and transmits combat-related player interactions (such as direct or indirect fire engagements).

The Small Arms Transmitter (SAT) is an integral component of the MILES gear. SAT simulates weapon performance by transmitting a laser beam from the shooter to the target whenever (blank) rounds are fired. This beam conveys the player identification code of the shooter and the type of weapon being fired. If the target receives a pulse from the SAT, then software within the target's harness decodes the pulse and determines the outcome of the simulated impact. The result of the engagement is transmitted to the OPCEN by the MILES gear.

Similarly, MILES provides a means for assessing the outcomes of indirect fire engagements. The Simulated Area Weapons Effects (SAWE) component of MILES

captures the OPCEN-provided coordinates at which area munitions (e.g., artillery, mortars, chemical, etc.) are detonated, compares them with the GPS-provided player coordinates, and issues an audible signal if the player-combatant is within the lethal radius of the detonation. Table 1, below, lists the various MILES components.

Table 1. MILES Components

Communications	Weapon systems
GPS antenna & receiver	M16 (SAT)
Shoulder mounted RF antenna	M249 (SAT)
Helmet harness & laser detectors	M203/M16 (SAT)
In-Room Positioning System transponder	M67 hand grenades
	Direct fire harness
	Indirect fire harness (SAWE)

5. Operations Center

The Operations Center (OPCEN) is the central control facility for all MOUT-IS exercises and, as a control facility, initializes and monitors all activities. Initialization entails establishing RF contact with players and determining their starting locations. Monitoring entails recording all actions as well as acting as a "facilitation cell" from which certain activities, such as call for indirect fire or player resurrection by on-field controllers/umpires, can be implemented.

The OPCEN also serves as an after-action review (AAR) station. In this capacity, the OPCEN can replay exercises (protocol data units, or packets, containing the entity state of all players which are captured and stored during exercises) and display their locations, movements, and interactions on a virtual terrain database that realistically models the Camp Lejeune MOUT site.

Formal AAR reports can also be generated from the archived data. These typically consist of details about the exercise, to include: kills, firing events, individual-fire team-squad-platoon locations and activities, fratricide, engagement ranges, and "near misses."

The following is a partial list of OPCEN equipment:

- DIS Interface
- 2D/3D Stealth Viewers
- SAT Alignment Computer and Assembly
- Manual SAR Boresight System
- Battery charges and equipment storage areas.

Section II presents a summary of the assessment process. It describes how each of these subsystems were tested and evaluated, and concludes with a discussion of what would be required to bring the instrumentation suite at Camp Lejeune “on line.”

II. ASSESSMENT PROCESS

A. PHASES

The assessment of the state of instrumentation at Camp Lejeune was conducted in two phases. The first phase was executed between January 12th and 14th, 2000, by a team of engineers from Lockheed Martin's Orlando facility. The purpose of this first phase was to perform an inventory and rapid inspection of the equipment at the MOUT site. This overview provided a basis for estimating the level of effort that would be required for a more in-depth inspection (the second phase).

MOUT-IS equipment housed in the MILES warehouse and the MOUT storage facility was inventoried and inspected. Indoor instrumentation equipment (mounted in the Strip Mall and the Bank) was inspected. Outdoor telemetry and repeater equipment (Church, Gym, and OPCEN) was also inventoried and examined.

1. First Phase

Based on the preliminary inspection and assessment, most of the instrumentation equipment at Camp Lejeune was judged to be intact. The only glaring exception was the microwave antenna outside the Bank building. This antenna and its associated electronics were destroyed when a helicopter blade struck the antenna housing. Some indoor equipment was damaged slightly from moisture and mildew. In particular, some connectors were damaged from moisture and mildew.

Repeaters (Gymnasium, Church, and OPCEN) were judged to be in good condition. The only missing pieces of equipment were two radios that could not be located in the Church RF telemetry cabinet. Over the 16 months of disuse, the microwave antenna at the Gymnasium had become mis-aligned, however, and a frequency shift had occurred in the microwave LAN components. These first phase observations are summarized below in Table 2.

Table 2. Missing and Damaged Equipment

	Indoor Instrumentation	Outdoor Instrumentation
Missing equipment	none	2 radios (Church)
Damaged equipment	corrosion	Microwave antenna (Bank)
Other factors	animal nests	Frequency shifts, antenna misalignment (microwave link between Gym and OPCEN)

The implication for the second phase of the assessment process was that hardwire links would be established between some of the buildings and the OPCEN in lieu of the pre-existing microwave connections. In particular, the Gym and the OPCEN would be connected by coaxial cable (apparently the Bank and the OPCEN were not connected by cable – or any other medium – in preparation for the second phase, although this microwave link between these two buildings had been destroyed). This enabled limited testing of range repeater systems connected to the OPCEN.

2. Second Phase

The second phase of the assessment was conducted on-site at Camp Lejeune during the last several weeks of January 2000. This phase involved the actual operational testing of sensors, weapons, and computers. Due to time and resource constraints (imposed in large part by infrastructure degradation, due to the lack of routine maintenance), however, this was not a full-up drill with all equipment synchronized and running in concert. Rather, this was a test of individual subsystems and the MILES third-generation equipment on a largely sequential basis.

a. Overview

To begin this phase, all indoor and outdoor tracking equipment was activated and initialized using software resident in the OPCEN or within the equipment itself. The actual equipment testing was then conducted in the following facilities: OPCEN, MILES warehouse, Strip Mall, Bank, and Gymnasium. Typically this entailed unpacking and booting computing equipment, testing some of the sensor equipment, setting up antennae, and installing transponders to verify measurements taken by player equipment.

In brief, this assessment revealed that the in-room tracking system was functional, but the microwave link between buildings and the OPCEN was not. While some indoor connectors were damaged, it was nonetheless possible to establish communications with a player unit. Regarding player equipment, the helmet transponders were in need of new batteries and they needed to be reprogrammed with new identifier codes.

The following paragraphs describe the building-by-building tests that were conducted, and the results of these evaluations.

b. OPCEN

The microwave LAN between the Bank and OPCEN was destroyed by the helicopter accident and therefore none of the in-room position data from the Bank could be displayed in the OPCEN. A hardware cable between the two facilities – such as the one used to connect the OPCEN and the Gymnasium in Phase I – would provide the same functionality as the microwave link, but would be cheaper and less susceptible to damage from future training activity.

The OPCEN computers that had been stored in the loft of Building 20 were unpacked and set up. Although they had been stored for some time, the primary systems appeared to boot correctly and present the proper logon messages. Limited testing of the OPCEN computers did not reveal any Y2K problems.

The GPS station in the OPCEN was tested and found to be functioning normally.

c. Bank

With the exception of two of the rooms, the indoor instrumentation in the Bank appeared to be in working order. The position system was tested by attaching a monitors to the building computers and observing the position of entities in the Bank. However, as discussed above, position data could not be displayed in the OPCEN. The failure within two of the Bank rooms was attributed to poor connectors or, possibly, the loss of a synchronization signal.

d. Strip Mall

The testing of the indoor positioning system in the Strip Mall was conducted in much the same manner as in the Bank. It too appeared to be in working order. Position data were displayed accurately on the attached monitors.

e. Gymnasium

The range repeater computer at the Gymnasium booted successfully and all indicator lights on the repeater itself indicated normal operation. The RF antenna for the repeater was installed (recall that a hardwire cable provided the communications link between the Gymnasium and OPCEN during this assessment phase), and channel filters were visually inspected.

f. Church

Very little testing occurred in the Church. In particular, its range repeater was not evaluated because two RF channels were missing from its electronics tray (located in the OPCEN).

g. MILES Equipment

In many cases, pieces of equipment, such as MILES grenades or direct-fire-vest sensors, failed to operate normally or at all. Often these failures were traced to batteries that had become corroded over long periods of disuse, or were producing less power due to cold conditions. In particular, the 3rd Generation MILES player vests and helmets contain imbedded 3.6-volt disposable batteries that power the laser detectors and other functions. As their components oxidized over time, resistance increased and, consequently, power output decreased. Similarly, other equipment (namely, the MILES hand grenades) used 5.0-volt batteries that also suffered from cold and corrosion. The following table (Table 3) summarizes the activities that were conducted in each facility.

Table 3. Facilities and Tests

Facility	Function/Tested Item	Result
OPCEN	▪ Computers were unpacked, set up, and booted up ▪ GPS reference station test ▪ Y2K compliance	▪ Booted successfully ▪ GPS functional ▪ Y2K compliant
Strip Mall and Bank	▪ Indoor position display (to OPCEN) ▪ Room sensors (tested with one helmet mounted ultrasonic sensor) ▪ System computers ▪	▪ Failed to display in OPCEN ▪ 2 Bank rooms did not initialize ▪ Sensors to system computers COM-link successful
Gymnasium	▪ Range repeater RF antenna was installed ▪ Range repeater and computer tested	▪ Successful installation ▪ Tested normally
Church	▪ Range repeater could not be tested due to channel unavailability	▪ Components of electronics tray missing
MILES Warehouse	▪ Two Smart Controller guns tested with working player vests ▪ 48 randomly sampled (out of 150) direct fire vests ▪ 30 randomly sampled (out of 150) direct fire helmet sensors ▪ Vest batteries (rechargeable 9-volt Lithium; GPS and vest transceiver) ▪ 30 randomly sampled (out of 150) hand grenades ▪ 30 randomly sampled Small Arms Transmitters (SAT) were tested for RF capability ▪	▪ Controller guns functioned normally ▪ < 20% vests functional (battery failure) ▪ No helmet sensors activated (battery failure) ▪ 80% vest batteries held charge ▪ No grenades gave normal audible signal ▪ SAT-RF bench test showed normal connectivity, MILES coding, player pairing, laser functioning

3. Repairs and Upgrades

There are several steps that should be taken to reconstitute the instrumentation suite at Camp Lejeune. The first is to replace outdated or damaged equipment. For example, most of the RF equipment in the repeater cabinets is obsolete and should be replaced. GPS

cards in repeater cabinets do not support the August 1999 modification of the GPS satellite-system's internal binary representation from 1's complement to 2's complement. These cards are obsolete and should be replaced.

Second, communications links between the OPCEN and the site buildings, in particular the Bank, should be re-established. Although these had been microwave links, the new connections should be hardwire cable. Hardwire cable is inexpensive, requires little or no maintenance, and is less vulnerable to damage such as that inflicted on the Bank antenna by the helicopter.

All 3.6-volt batteries in SATs, player vests, and helmet sensors should be replaced. Many of these batteries have oxidized and no longer are reliable power sources. Similarly, all 5.0-volt batteries in MILES grenades should be replaced. Helmet transponders (75 of them) need to be reprogrammed with new identification codes.

OPCEN PCs are six years old[1] and their operating systems are SCO Unix. By current standards, this is an antiquated system and should be upgraded. Because of their age, any PC failure would require new hosts to support OPCEN functions (after-action reviews, or range, telemetry, graphics, and exercise control).

Finally, more detailed equipment testing – possibly at the laboratory level – should be conducted in certain cases. Candidate equipment includes all MILES direct fire vests, helmet sensors, grenades, and SATs. Electronic equipment contained in the RF repeater cabinets is obsolete and should be replaced. On the other hand, the existing cabinets, RF antennae, filters, and mounts are in excellent condition and should be retained. Power supplies are also in good working order. Table 4 summarizes[2] by sub-system the tasks that need to be performed.

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1 These computers – and microwave components – were government furnished equipment from 29-Palms and may have been well over six years old at the time of the assessment.

2 Table 4 is extracted from Lockheed-Martin, "*Military Operations in Urban Terrain,*" ibid.

Table 4. Tasks by Subsystem

Indoor instrumentation	OPCEN Computers	Range Repeaters	Player Equipment (test - repair or replace)
Perform Continuity Checks	Power-up computers	Perform continuity checks	Box, pack, & ship to Orlando
Perform System Power Checks	Upgrade computers	Perform System Power Checks	Direct fire equip
Replace Digital Board	Re-host new software	Replace RF transceivers	Indirect fire equipment
Tracking infrastructure (repair or replace)	Install system software	Replace Communications PCs	SAT
Establish LAN communications	Conduct subsystem tests	Replace GPS receivers	Grenades
Reprogram helmet transponders	Verify system performance	Replace microwave LAN	Lithium-Ion Batteries
Conduct subsystem tests	Generate documentation	Align antennae	Box, pack, & ship to Lejeune
Verify system performance	Full-up system test	Perform RF spectrum checks	
Generate documentation			
Full-up system test			

As indicated in Table 4, both the indoor instrumentation and the range repeaters should be subjected to continuity and power checks. Also, player equipment must be packed and shipped to Orlando, FL, for laboratory testing, then re-boxed and shipped back. Finally, full-up systems tests should be conducted on the indoor instrumentation and the OPCEN computers (equipment tests in the assessment phase were largely conducted in a stand-alone manner).

B. COST ESTIMATES

1. Restoration Costs

The discussion in this section is an attempt to quantify the costs of restoring the instrumentation at Camp Lejeune and keeping the facility in working order once repairs have been made. This section also contains cost estimates for removing and relocating the instrumentation to another site if that ever becomes a desirable strategy.

Estimates of the material costs and the number of engineering hours required to perform the repairs are presented in Table 5 for the four major instrumentation subsystems: indoor instrumentation, OPCEN computers, range repeaters, and the MILES player equipment. All estimates are based on the tasks listed in Table 4. In addition, the number of round trips the engineering task force will have to make to the Lejeune facility from their home location (and back) is included in Table 5.

Table 5. The Repair Hours and Material Costs

Sub-system	Indoor Instrumentation	OPCEN Computers	Range Repeaters	Player Equipment	Total
Eng. hours	640 (16 wks)	720 (18 wks)	720 (18 wks)	1280 (32 wks)	3360 (84 wks)
Material $K	50	100	150	100	400
Round trip flights	4 (4 wks/trip)	4 (4.5 wks/trip)	4 (4.5 wks/trip)	0	12

Depending on staffing and the number of tasks that can be performed concurrently, the restoration will require between four and a half to thirteen weeks to complete.

The following chart (Figure 3a) displays estimates of the cost of performing these subsystem repairs when the hourly engineering rate varies between $50/hr and $200/hr. Each of the sub-system estimates contains the embedded travel, material, and labor costs. Travel expenses were estimated at $1500 per person per 40-hour week plus $200 per round trip ticket.[3] Airline ticket prices were estimated from round trip fares between Orlando and Raleigh-Durham, as posted on the Internet.

3 It is important to note that there is no travel prescribed for the player equipment repair functions; thus travel expenses are based on 12 round trips and only 2080 hours – or 52 weeks – away from the home facility.

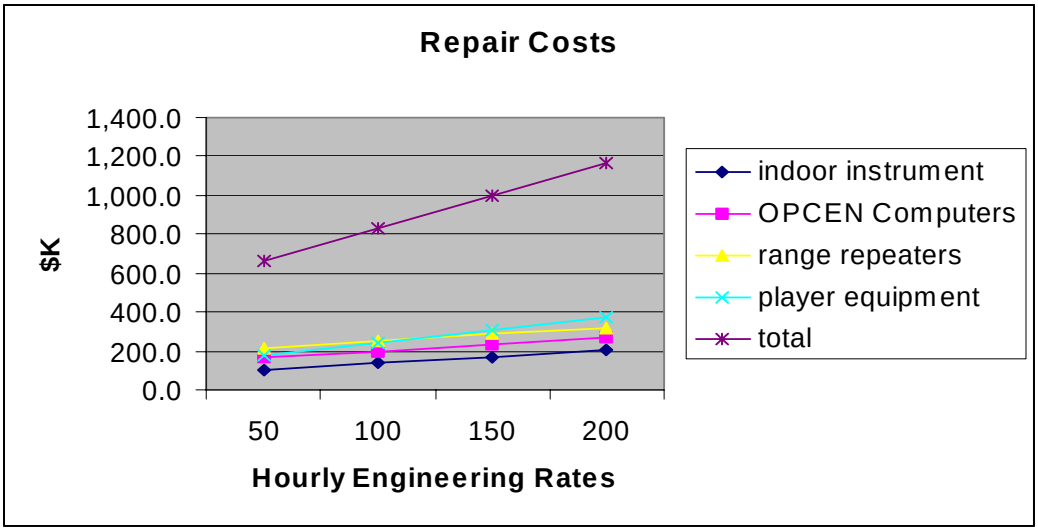

Figure 3a. Repair Costs by Subsystem

Figure 3b presents the same repair cost information based on the amount of engineering effort, materials, and nominal travel expenses. From either chart (3a or 3b) it is evident that the burden for repairing the instrumentation at Camp Lejeune is on the order of one million dollars ($800K at $100/hr). The next few sections will present cost estimates for maintaining the site and, if necessary, for moving the instrumentation to a different location. These will show that the repair costs, while substantial, are approximately 50 percent more than the annual cost of maintaining the site.

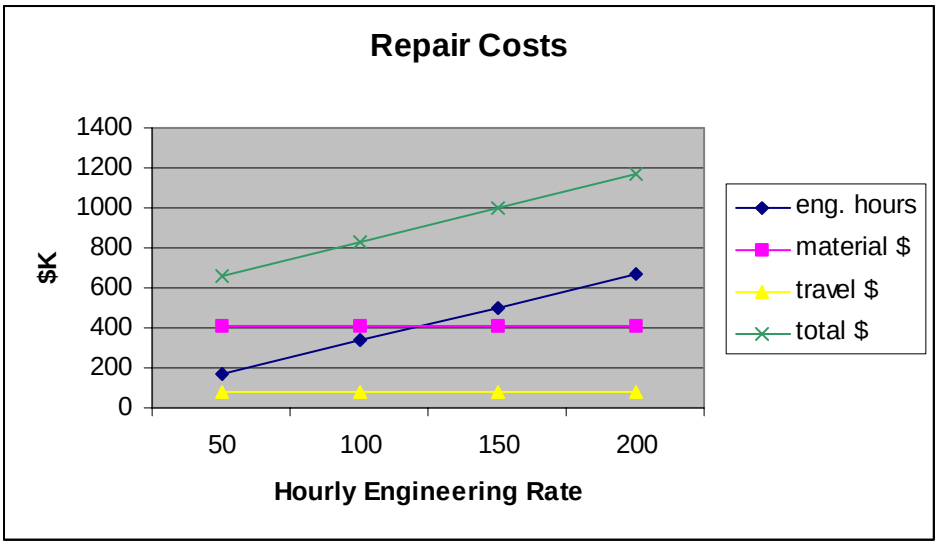

Figure 3b. Engineering, Material, and Travel Costs

2. Maintenance

Once the MOUT site is repaired and restored, it will be necessary to maintain the site in order to keep it functioning at an operational level. The personnel required for this purpose include the following:

- Site manager
- OPCEN computer operator
- Technicians (2).

These positions are full-time positions. In addition, a yearly parts and repair cost is a likely expenditure. Figure 4 estimate the cost of maintaining the facility if the hourly wages of these personnel fall between $30/hr and $90/hr. A nominal $100K parts and repair cost is included (this is based on past experience, but may vary widely from year to year).

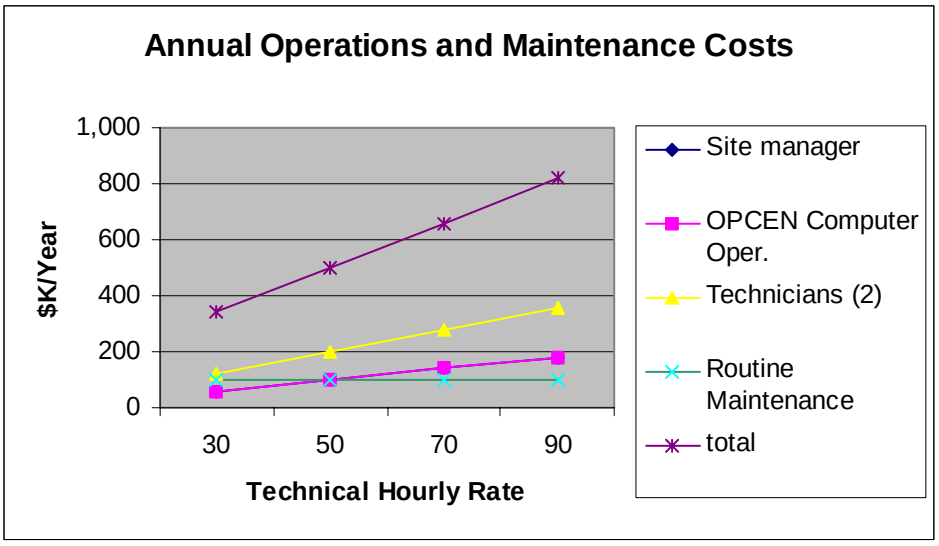

Figure 4. Annual Operations and Maintenance Costs

These operating costs are substantial. The nominal hourly rate ($50/hr) implies a yearly outlay of one half million dollars to keep the facility functioning. This potential operating burden may be a factor keeping the site in a state of limbo.

3. Removal and Relocation

Once the repairs have been made, it may be more desirable to remove the instrumentation suite to an alternative site other than Camp Lejeune; the rationale for this will be

discussed briefly in a later section of this paper. If this (removal and relocation) is the desired course of action, several things need to be done to ensure that removal and reinstallation are done properly and efficiently. In particular, the subsystems listed above (indoor instrumentation, OPCEN equipment, range repeaters, and MILES gear) have to be inventoried, removed and packed. Cosmetic repairs need to be performed, and shipping arrangements made. At the receiving site (assuming it meets structural and power criteria) surveys need to be conducted, equipment unpacked, and buildings prepared to receive the instrumentation. And the subsystems need to be installed and tested in a full-up drill. Also, documentation for the new site should be prepared.

The costs for these operations are estimated in Table 6 below. They are "broken down" by functions at each terminus and, as above, presented in terms of engineering hours, material (and shipping) costs, and travel. Table 6. Removal, Relocation, and Reinstallation:

Table 6: Engineering Hours, Material, and Travel

Function	Box, Pack, and Ship	Unpack and Re-Install	Total
Eng. hours	360	1280	1640
Material/Shipping $K	50	35	85
Round trips	4 (3 wks per trip)	8 (4 wks per trip)	12

The cost for removal (tear down), relocation, and installation are presented in Figure 5. Again, the engineering hourly rates are varied between $50/hr and $200/hr. Material and shipping costs are included; travel expenses are estimated as before.

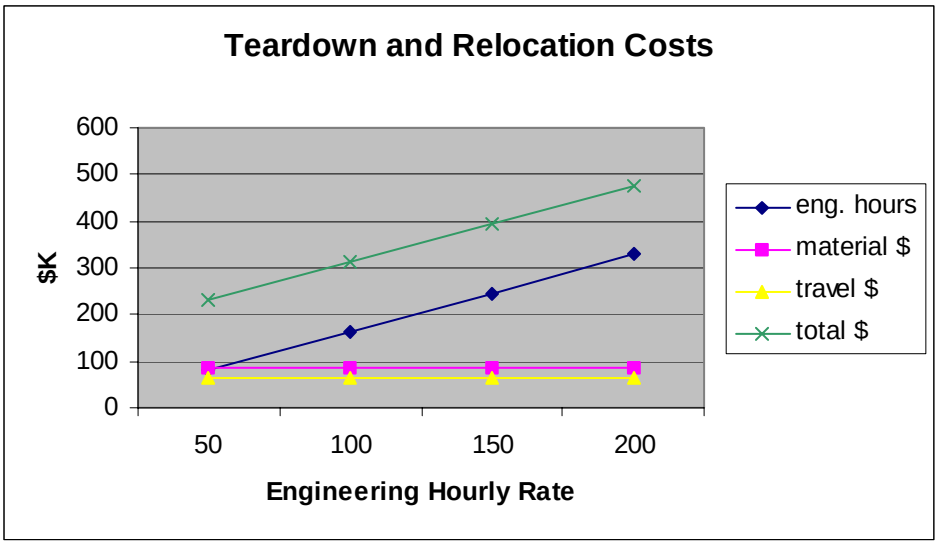

Figure 5. Removal, Relocation, and Reinstallation Costs

Thus, at a nominal $100/hr rate for engineering assistance, the cost of relocating at a site that meets structural and power requirements is estimated to be on the order of $300K. While this is substantial, it is less than the yearly maintenance cost of the instrumented site and considerably less than the repair costs alone.

Figure 6, below, shows the total cost of repairing the instrumentation at Camp Lejeune, then removing it and relocating it at an alternative site. Again, engineering rates are assumed to be between $50 and $200/hr. Costs are broken out for the various subsystems and functions that would be performed in this venture and are displayed together with the total cost of the combined operation. At the nominal $100/hr rate, the total cost is on the order of 1.1 million dollars.

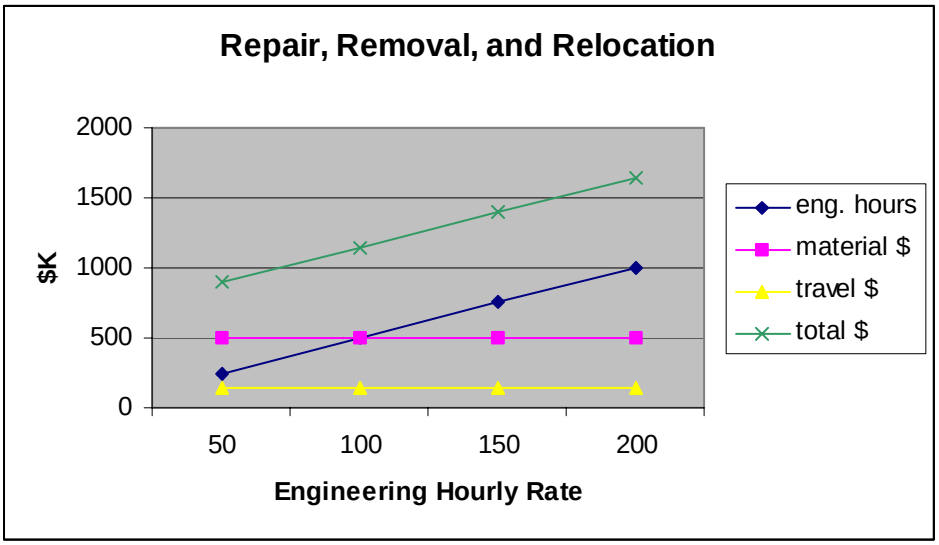

Figure 6. Combined Costs of Repairing and Relocating Instrumentation

This completes the assessment portion of this paper. The next section discusses some of the options and choices for the future disposition of the instrumentation at the Camp Lejeune MOUT site. The cost and labor data developed in this section will provide the basis for much of the next section. Before proceeding with this discussion, certain issues related to the MOUT site itself bear examination.

C. ENHANCEMENTS TO THE INSTRUMENTATION SUITE

1. Video

If the instrumentation suite becomes operational in the future (regardless of whether it remains at Lejeune or moves to an alternative site), certain enhancements to the sensor suite might be desirable. In particular, the addition of video equipment inside and outside would give observers and analysts detailed information about the movement, direction, and field-of-view of combatants within the buildings. This would enhance the utility of the suite as an aid in developing tactics, techniques, and procedures (TTPs). The current instrumentation suite only provides players' positions and identification tags.

2. Cost Estimate for Video

Cost estimates for video equipment vary considerably, depending on the capabilities of the desired system. For example, indoor cameras with full day-night lenses are estimated by STRICOM to cost over $11K per unit. Estimates for outdoor cameras with the same full day-night capability are even higher. On the other hand, Camcorders with image

intensifiers (the major cost element) can be acquired for approximately $4K per unit – assuming a 30 unit purchase. The system proposed by STRICOM is largely based on a commercial off-the-shelf-technology (COTS). It includes a control room (possibly in the OPCEN), and an additional monitoring station in the office of the Gunnery Sargent who has day-to-day site responsibility. The control room would include the following equipment:

- Control consoles and equipment racks
- Digital After Action Review Technology (DAART)
- Video Switch (48 input channels, 16 output channels)
- 3 monitors
- 8 independent preview channels
- 4 independent digitally recorded channels
- 4 independent analog recorder channels (VHS)
- Video editor.

STRICOM's estimate of the cost of this control facility is $150K; outfitting the Gunnery Sargent's office would cost an additional $5K; installation and experimental support costs are estimated to be an additional $150K.

The following table contains the cost estimates and cost elements for a less elaborate system – one that does not include the control facility. It is based in STRICOM's estimate of the video requirement to support a single experiment at the Lejeune facility.

Table 7. Video Elements

Cameras	Image Intensifiers	"Sunk" Costs
Camcorder	Night vision illuminator	Installation
Batteries	Batteries	Management
10 VHS tapes	Mounting kit	Misc. Equip
Tripod or mounts		Travel
$1.25K per unit	$2.75K per unit	$90K

D. CONCLUSIONS

1. The Use of Instrumented Buildings

The Lejeune MOUT site facility is used on a regular basis to train Marines to conduct operations in urban terrain. The site contains over 20 buildings; however, some or all of the four-instrumented buildings, the Church, Gymnasium, Bank and Strip Mall, are not used during training exercises. While the rationale for excluding these buildings is not entirely clear,[4] it is apparent that the presence of inoperative instrumentation has a negative impact on the MOUT facility (with possible ramifications for the utility of the site for training).

This raises the issue of why the instrumentation remains on site at Lejeune; it should either be repaired and the system brought "back on line," or it should be removed and relocated at another MOUT site. There are many factors favoring the restoration of the instrumentation at Lejeune. These include, but are not limited to, the availability of MILES support on site, the proximity to the Marine Corps Warfighting Laboratory, and the absence of relocation costs. However, in order for the site to be brought back on line, a proponent must be found who is willing to provide funding to cover the substantial yearly maintenance expenditures.

2. Relocating to Range 9 at Quantico,VA

If the operational costs at Lejeune continue to prove prohibitive, then two options should be considered: either the instrumentation suite should be dismantled and discarded, or an alternative MOUT site should be considered. In either case, all the buildings at Lejeune would become available for training – instead of the approximately 16 out of 20 that are available now.

The second option, an alternative site, has certain attractive features: the "sunk costs" of the Lejeune site would be partially recovered and an active facility would become available. One candidate site is the MOUT facility ("Range 9") at Quantico, VA. While this un-instrumented facility is smaller than Lejeune's (only 15 buildings as compared to over 20), it has the advantage of being available to the USMC and a wide variety of government agencies (FBI, DEA, Capitol Police, etc). Furthermore, the PM Training

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4 The MOUT facility at Camp Lejeune falls under the authority of the II Marine Expeditionary Force (II MEF), while the instrumentation at the site is controlled by the Marine Corps Warfighting Laboratory. This dichotomous arrangement may have bearing on the disposition of the site.

Systems at Quantico is interested in developing the facility and would welcome an instrumented testbed at their MOUT site.[5] The instrumentation suite at Lejeune – pending an endorsement of the transfer by the Marine Corps Warfighting Laboratory – could be the basis for such a facility. Other possible locations include Camp Pendleton and 29 Palms. Pendleton has MILES support in place and supports certain technical programs (for example, EPLRS), but no available MOUT facility at the current time. On the other hand, 29 Palms does have a MOUT facility and MILES support. However, it is unlikely that the instrumentation suite would be moved to the West Coast (both a cost and a "balance" issue), making both Camp Pendleton and 29 Palms improbable candidates.

5 As evidence of their interest, the PM for Training Systems/MARCORSYSCOM at Quantico is in the process of acquiring enough MILES 2000 equipment to outfit 10 battalions.

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13. ABSTRACT (Maximum 200 words)

The Military Operations in Urban Terrain (MOUT) site at Camp Lejeune is an active and vital training facility. In 1998, some of the buildings in this site were “instrumented” with sensors and communications equipment in order to collect and transmit engagement data generated during live MOUT exercises. The instrumented facilities have not been used since the summer of 1998 and have, in part, been damaged or fallen into disrepair in the interim. The cost of restoring the instrumentation system at Camp Lejeune is estimated at nearly one million dollars. Removing and repairing the equipment then installing it at another MOUT site would be more costly, but might provide a productive means of utilizing the instrumentation.

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